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(54) Cutting, grinding and milling.

(57) A cutting, grinding or milling machine comprises a chuck (62) for holding a workpiece (20), a cutting, grinding or milling tool spindle (12) positioned, in relation to the chuck (62), so that the tool (14) may be brought into contact with such a workpiece (20) when it is held by the chuck (62); and drive means (17) connected to bring about relative movement between the spindle (12) and the chuck (62) such that the contact between the tool (14) and the workpiece (20) when the machine is in use moves in a generally circular path around the workpiece (20). A coolant nozzle manifold (40) is mounted to direct coolant at such contact, the chuck (62) and the manifold (40) being rotatable relative to one another to enable the manifold (40) to keep coolant trained on such contact as it moves around the workpiece (20). A cam (44) is fixed relative to the manifold (40), and is engaged by a sleeve (15) surrounding the spindle (12) to advance or retard relative rotation between the workpiece (20) and the manifold (40) in dependence upon relative radial movement between the tool (14) and the workpiece (20) when the machine is in use, to keep the coolant directed at such contact notwithstanding such relative radial movement.

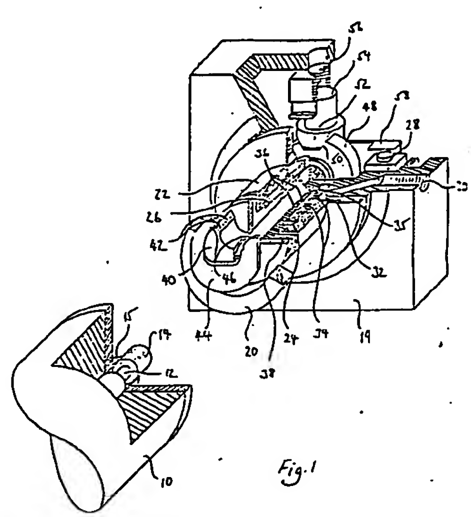

Fig. 1

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Description

Cutting, grinding and milling

The present invention relates to a cutting, grinding or milling machine and to a method of cutting, grinding or milling.

In creep feed grinding, in which a surface to be ground is traversed once or more by a grinding wheel to effect the desired depth of grinding along the surface, the speed with which a point on the grinding wheel cuts the surface which it is grinding is usually in excess of thirty metres per second. An immense amount of heat is therefore generated by friction. In addition, further heat is generated by plastic deformation of the metal. This is removed by means of a jet of coolant fluid, such as neat oil or an oil in water emulsion, which is directed at the point of contact between the grinding wheel and the workpiece. To be effective, the speed with which the coolant fluid is so directed needs to be at least the same order of magnitude as the speed with which a point on the grinding wheel cuts the surface of the workpiece. Furthermore, the jet needs to be directed fairly accurately at the point or region of contact. For a linear traverse, this can be performed relatively easily by keeping the jet nozzle or nozzles in a fixed position relative to the grinding wheel. However, it is difficult to maintain this condition when a generally circular traverse is required, particularly if the traverse involves movement of the contact in a radial direction.

The present invention seeks to overcome this problem.

Accordingly, the present invention is directed to a cutting, grinding or milling machine for cutting, grinding or milling a workpiece along a generally circular path, in which coolant directing means are provided to keep coolant fluid directed at the position of cutting, grinding or milling.

In one form of the present invention, there is provided a cutting, grinding or milling machine comprising holding means for holding a workpiece, a cutting, grinding or milling tool spindle positioned, in relation to the holding means, so that the tool may be brought into contact with such a workpiece when it is held by the holding means, drive means connected to bring about relative movement between the spindle and the holding means such that the contact between the tool and the workpiece when the machine is in use moves in a generally circular path around the workpiece, coolant directing means mounted to direct coolant at such contact, the holding means and the coolant directing means being rotatable relative to one another to enable the coolant directing means to keep coolant trained on such contact as it moves around the workpiece, and adjustment means connected to advance or retard relative rotation between the workpiece and the coolant directing means in dependence upon relative radial movement between the tool and the workpiece when the machine is in use, to keep the coolant directed at such contact notwithstanding such relative radial movement.

The present invention extends to a method of cutting, grinding or milling a workpiece along a generally circular path, in which coolant is kept directed at the position of cutting, grinding or milling.

One method embodying the present invention comprises bringing a rotary cutting, grinding or milling tool into contact with a workpiece, causing relative movement between the tool and the workpiece such that the contact between the tool and the workpiece moves in a generally circular path around the workpiece, directing coolant at such contact by coolant directing means, causing relative rotation between the coolant directing means and the workpiece to keep coolant trained on such contact as it moves around the workpiece, and advancing or retarding the relative rotation between the workpiece and the coolant directing means in dependence upon relative radial movement between the tool and the workpiece, to keep the coolant directed at such contact notwithstanding such relative radial movement.

An example of a machine made in accordance with the present invention is illustrated in the accompanying drawings, in which:-

Figure 1, shows a perspective partly cut-away view of the main parts of the machine; and

Figure 2 shows a diagrammatic elevational view of the machine.

The parts shown in Figure 1 comprise an electric motor 10 through a central axis of which extends a grinding tool spindle 12 on the end of which is secured a grinding wheel 14. A sleeve 15 extends outwardly from a front plate of the motor 10, and surrounds one end of the spindle 12. It is fixed to the front plate of the motor 10 so that it remains stationary when the wheel 14 rotates. The motor 10 drives the spindle 12 to rotate it many tens of thousands of revolutions per minute, so that the speed of a point on the surface of the wheel 14 is in excess of 30 metres per second. A support 17 (shown in Figure 2) for the motor 10 enables the latter to be moved accurately in three mutually perpendicular directions in a manner known per se, under the control of a computer 18 which affords CNC operation.

A housing block 19 is provided with a bearing sleeve 22 within and along a central axis of which extends a hollow rotary spindle 24. Bearings 26 are provided in the sleeve 22 to facilitate rotation of the spindle 24 about its elongate axis.

A coolant duct 28 extends from a port 30 on the outside of the housing block 19 through to an interior 32 of the bearing sleeve 22. Apertures 34 in a further sleeve 35 between the sleeve 22 and the spindle 24 and apertures 36 in the spindle 24 enable coolant fluid to pass into the interior of the hollow spindle 24 to a forward end 38 thereof adjacent to the workpiece 20. Mounted on this forward end 38 is a manifold 40 comprising a line of jet nozzles 42 directed tangentially relative to the spindle axis. The line of the nozzles 42 extends in the direction of the axis of the spindle 24. The interior of the spindle 24 is

in communication with the jet nozzles 42 via the interior of the manifold 40.

A cam 44 is attached to the front end of the manifold 40. The cam is generally U-shaped, with the inside surfaces 46 of the arms thereof curving in a generally clockwise direction viewing the machine as in Figure 1, and progressing radially away from the axis of the shaft 24, so that they extend in a tangential direction at their outer extremities. These inside surfaces 46 are the cam surfaces. The spacing between the cam surfaces 46 is equal or substantially equal to the outer diameter of the sleeve 15, and remains constant with increasing distance from the axis of the spindle 24.

Within and to the rear of the housing block 19 there is provided a lock ring 48 attached to the rear end of the spindle 24. The ring 48 is provided with a notch 50 which can be engaged by a lock 52 on a piston 54 to prevent the spindle 24 rotating. A pneumatic cylinder 56 is mounted on the housing block 19 and receives the piston 54 to facilitate movement thereof in a verticle direction to engage or disengage the lock 52 in the locking ring 48. A further piston and cylinder arrangement (not shown) is provided on the underside of the lock 52. Thus air pressure in the cylinder 56 urges the lock 52 downwardly, and pressure in the other cylinder urges it upwardly. A proximity switch 58 is provided to give an indication of when the lock is engaged.

It will be seen from Figure 2 how the workpiece 20 is held between the jaws 60 of a chuck 62 which is mounted on the same plate 64 as the housing 19. The plate 64 is in turn mounted on the same base 66 of the machine as the support 17.

In operation, the electric motor 10 is moved towards the chuck 62 so that the sleeve 15 is received between the arms of the cam 44. The grinding wheel 14 is then rotated at high speed in a clockwise sense viewing the machine as in Figure 1, and as it is rotated it is urged outwardly against the inside surface of the workpiece 20 so that it grinds the latter away to the required depth at the initial position of contact of the grinding wheel on the workpiece. The length of the sleeve 15 is sufficient to allow for axial oscillations of the motor 10 without the sleeve disengaging the cam 44. This position is clearly defined by reference to the parking position of the locking ring 48. While the grinding wheel 14 is grinding the workpiece 20, coolant fluid is forced at high pressure through the inlet port 30 to the jet nozzles 42 via the interior of the spindle 24 so that the fluid is trained accurately on the position of contact between the wheel and the workpiece.

While the workpiece 20 is held stationary, the lock 52 is disengaged and the motor is moved in a generally circular path following the generally circular inside surface of the workpiece 20. As it does so, it rotates the cam 44 together with the manifold 40 of the hollow shaft 44 by virtue of the engagement of the sleeve 15 with the cam 44, and the fact that the spindle 24 is free to rotate in sympathy with movement of the wheel motor 10 in this manner. As a result, the nozzle jets 42 precede the wheel 14 as it moves around the inside of the workpiece 20, and coolant is continually trained on the contact between the wheel and the workpiece notwithstanding the movement of the wheel. On completion of the generally circular path, the lock 52 is re-engaged, and the spindle wheel 14 is withdrawn.

In the event that the wheel 14 is required to cut more deeply into the workpiece 20 at a particular position thereof, the wheel 14 is moved under the control of the computer 18 further away from the axis of the shaft 24. Were it not for the curving of the inside surfaces 46 of the two arms of the cam 44, this would result in the coolant jets being trained on a position of the rotated wheel 14 that is inwards of the contact between the wheel and the workpiece. This in turn would result in overheating of both the wheel and the workpiece. However, because the inside surfaces 46 are curved as described herein, the outward movement of the wheel 14 causes the cam 44, and with it the manifold 40 and the shaft 24, to be advanced in an anti-clockwise direction viewing the machine as in Figure 1, so that coolant is kept trained on the contact between the wheel 14 and the workpiece 20. Similarly, if the wheel is moved radially inwardly towards the shaft of the axis 24, the engagement of the sleeve 15 with the inside surfaces 46 causes rotation of the manifold 40 to be retarded, and the coolant fluid to be kept trained on the contact between the wheel 14 and the workpiece 20.

Numerous variations and modifications to the machine will readilly occur to a person familiar with the art of grinding, without taking it outside the scope of the present invention. For example, the relative movement of the manifold 40, to advance or retard its angular position relative to the grinding wheel 14, can be effected by a motor controlled by computer rather than by the mechanical method which uses the cam 44. If the manifold 40 is rotated backwards by a whole turn after every grinding turn, so that it never turns through more than 360°, the coolant fluid could be fed direct to the manifold 40 via flexible tubing rather than through the illustrated passageways.

Claims

1. A cutting, grinding or milling machine for cutting, grinding or milling a workpiece (20) along a generally circular path, characterised in that coolant directing means (40) are provided to keep coolant fluid directed at the position of cutting, grinding or milling.

2. A cutting, grinding or milling machine comprising holding means (62) for holding a workpiece (20), a cutting, grinding or milling tool spindle (12) positioned, in relation to the holding means (62), so that the tool (14) may be brought into contact with such a workpiece (20) when it is held by the holding means (62), drive means (17) connected to bring about relative movement between the spindle (12) and the holding means (62) such that the contact between the tool (14) and the workpiece (20) when the machine is in use moves in a generally circular path around the workpiece (20), char-

acterised in that coolant directing means (40) are mounted to direct coolant at such contact, the holding means (62) and the coolant directing means (40) being rotatable relative to one another to enable the coolant directing means (40) to keep coolant trained on such contact as it moves around the workpiece (20), and in that adjustment means (44) are connected to advance or retard relative rotation between the workpiece (20) and the coolant directing means (40) in dependence upon relative radial movement between the tool (14) and the workpiece (20) when the machine is in use, to keep the coolant directed at such contact notwithstanding such relative radial movement.

3. A cutting, grinding or milling machine according to claim 2, characterised in that the adjustment means (44) comprises a coupling member (44) which couples movement between the spindle (12) and the coolant directing means (44) to advance or retard relative rotation between the workpiece (20) and the coolant directing means (40) in the manner set out in claim 2.

4. A cutting, grinding or milling machine according to claim 3, characterised in that the coupling member (44) comprises a cam (44) which is fixed relative to the coolant directing means (40), there being a part (15) which is fixed relative to the spindle axis and which engages the cam (44) to advance or retard relative rotation between the workpiece (20) and the coolant directing means (40) in the manner set out in claim 2.

5. A cutting, grinding or milling machine according to claim 4, characterised in that the cam (44) comprises curved portions which are spaced apart from one another to define a curved space therebetween which receives the said part (15) constituted by a sleeve which surrounds the spindle (12).

6. A cutting, grinding or milling machine according to claim 5, characterised in that the cam (44) comprises a U-shaped member (44) the arms of which constitute the said curved portions.

7. A method of cutting, grinding or milling a workpiece (20) along a generally circular path, characterised in that coolant is kept directed at the position of cutting, grinding or milling.

8. A method of cutting, grinding or milling a workpiece, comprising bringing a rotary cutting, grinding or milling tool (14) into contact with a workpiece (20), causing relative movement between the tool (14) and the workpiece (20) such that the contact between the tool (14) and the workpiece (20) moves in a generally circular path around the workpiece (20), characterised by directing coolant at such contact by coolant directing means (40), causing relative rotation between the coolant directing means (40) and the workpiece (20) to keep coolant trained on such contact as it moves around the workpiece (20), and advancing or retarding the relative rotation between the workpiece (20) and the coolant directing means (40) in dependence upon relative radial movement between the tool (14) and the workpiece (20), to keep the coolant directed at such contact notwithstanding such relative radial movement.

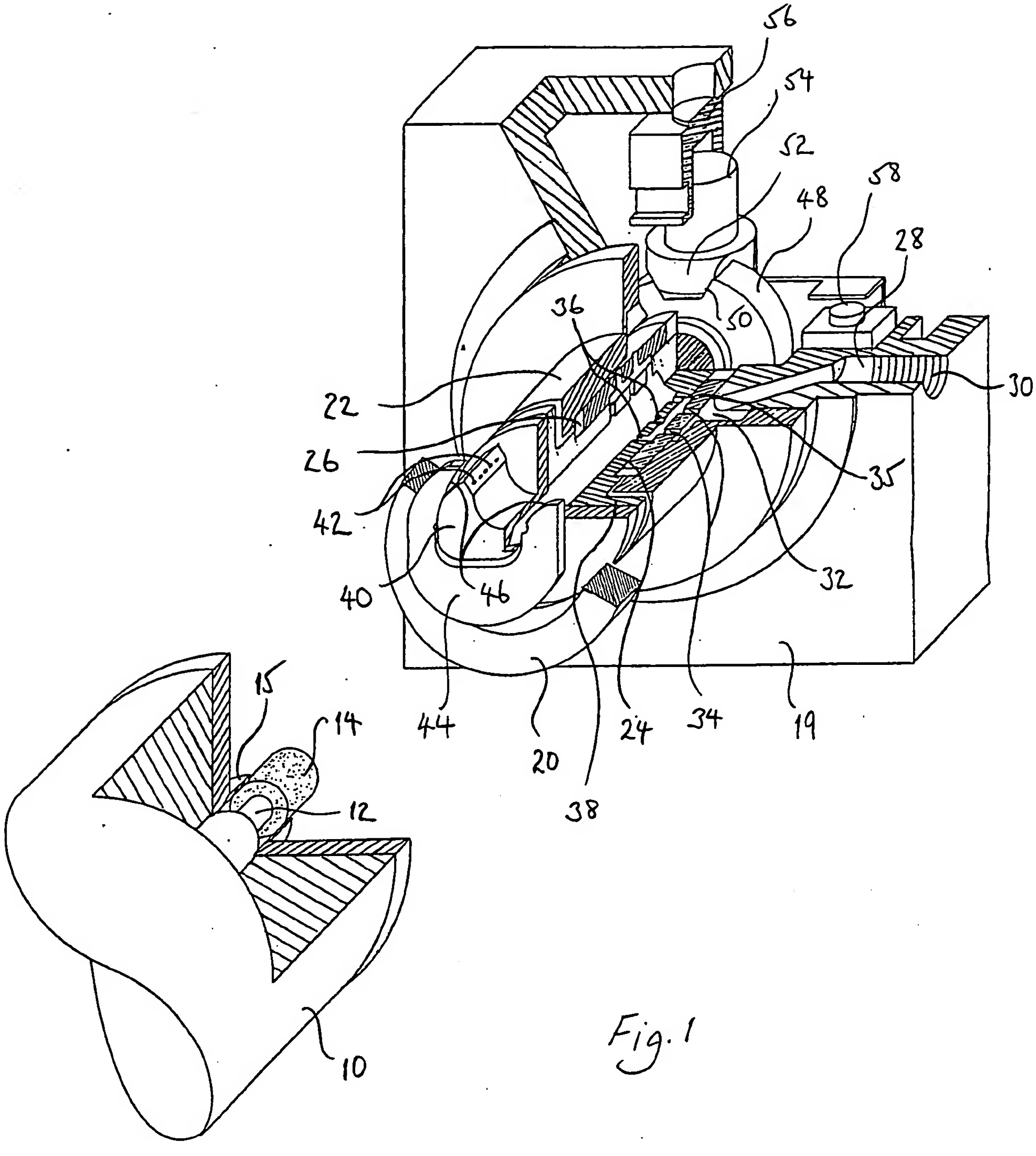
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Fig. 1

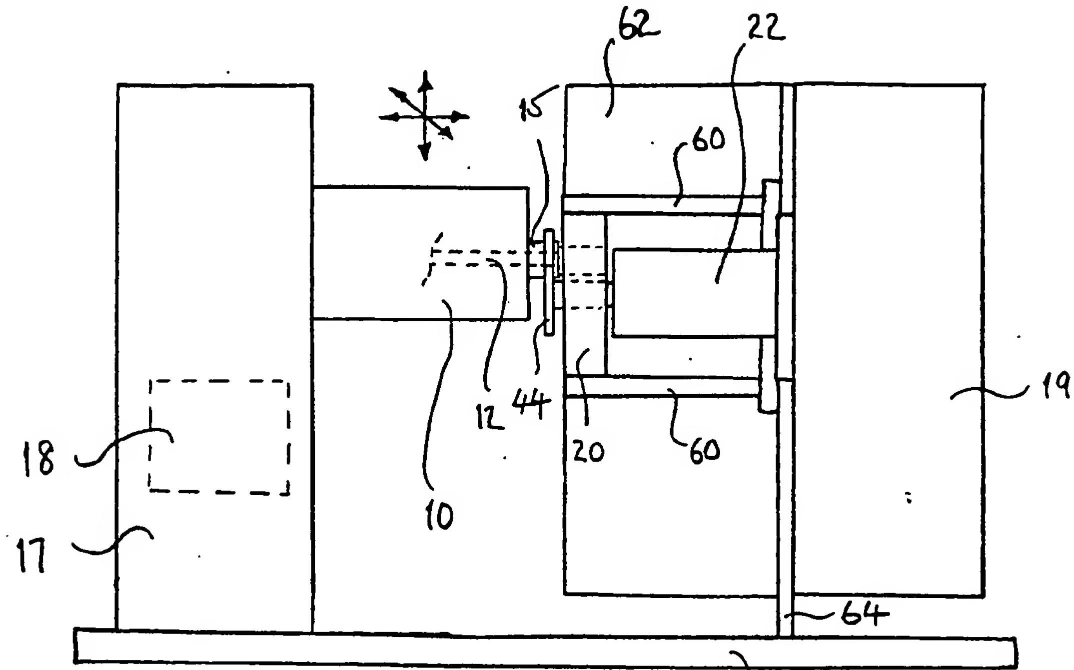

Fig. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 30 1993

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	EP-A-0 166 407 (MATSUSHITA) * Claim 1 *	1,7	B 23 Q 11/10 B 24 B 55/02
A		2,3,8	
A	EP-A-0 170 899 (FLACHGLASS)	1-3,7,8	
A	WO-A-8 401 737 (WEKON)	1-3,7,8	
A	DE-A-2 905 579 (HECKERT)	1-3,7,8	
A	FR-A-2 537 486 (KABUSHIKI)	1-3,7,8	
A	GB-A- 954 950 (HUTTON)	1-3,7,8	
A	JP-A-62 136 371 (MITSUBISHI)	1-3,7,8	
A	JP-A-57 156 147 (MATSUURA)	1-3,7,8	
A	JP-A-62 228 351 (GENICHI)	1-3,7,8	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)
B 23 Q B 23 B B 23 C B 23 D B 24 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13-06-1989	DE GUSSEM J.L.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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